OPEN BOOK/CLOSED NOTES EXAM. You are also allowed to reference not more than two 8-1/2"x11" prepared sheets of notes.

YOU MUST WORK “Section 0”. This will be your “Final Exam” and will count as 28% of your final grade. You may optionally work any section(s) from 1-4. Your score on this optional portion will replace your corresponding test score.

**Section 0 (You MUST work this section)**

1) An acetylene torch uses only oxygen (not AIR) for combustion. Determine the amount of “excess oxygen” that will need to be supplied to limit the temperature of the products to 3000 K. Assume adiabatic combustion.

2) A jet engine operating on Brayton Cycle propels an aircraft at 500 km/hr through atmospheric air at 30 kPa and 10°C. The pressure ratio for the cycle is $r_p = 12$, and all components may be assumed ideal except for the turbine, which has an isentropic efficiency of $\eta_{is} = 85\%$. The temperature of the air entering the turbine is 1500K. Determine the required mass flow rate of air to achieve a thrust of 1000 N. Assume variable specific heats.

3) Moist air at 100 kPa, 20°C, and 100% relative humidity is to be dehumidified to 20°C and 50% relative humidity. The only way to do this is to pass the air over a cold coil to condense the water (process 1-2) and then reheat the air to 20°C (process 2-3). Assume that the condensate ($f$) and the air leaving the coil (2) are both at 10°C.
   a) How much moisture must be removed from the air? (kg H$_2$O/kg AIR).
   b) How much heat must be removed in process 1-2?
   c) How much heat must be added in process 2-3?

**Section 1 (Optional – this will replace Test #1)**

1) Consider an ideal reheat-regenerative Rankine cycle with one open feedwater heater. The boiler pressure is 10 MPa, the condenser pressure is 15 kPa, the re heater pressure is 1 MPa, and the feedwater pressure is 0.6 MPa. Steam enters both the high- and low-pressure turbines at 500°C.
   a) Show the cycle on a T-s diagram.
   b) Determine the fraction extracted for regeneration.
   c) What is the thermal efficiency of the cycle?

**Section 2 (Optional – this will replace Test#2)**

1) The compression ratio of an air-standard Otto cycle is 9.5. Prior to the isentropic compression process, the air is at 100 kPa, 17°C, and 600 cm$^3$. The temperature at the end of the isentropic compression process is 800 K. Using specific heat values at room temperature, determine
   a) The highest temperature and pressure in the cycle.
   b) The amount of heat transferred (kJ).
c) The thermal efficiency.
d) The mean effective pressure.

2) An air-standard Diesel cycle has a compression ratio of 16 and a cutoff ratio of 2. At the beginning of the compression process, air is at 95 kPa and 27°C. Accounting for the variation of specific heats with temperature, determine

a) The temperature after the heat addition process.
b) The thermal efficiency
c) The mean effective pressure.

Section 3 (Optional – this will replace Test#3)

1) A refrigeration cycle with a 300 kJ/min cooling capacity operates on an ideal vapor-compression cycle, except that the compressor has an adiabatic efficiency of 85%. Refrigerant-134a is the working fluid, and R-134a enters the compressor at 140 kPa and is compressed to 800 kPa.

a) Show the cycle on a T-s diagram.
b) What is the quality of the mixture entering the evaporator?
c) What is the coefficient of performance?
d) What power input to the compressor is required (kW)?

2) An air conditioning system operates at a total pressure of 95 kPa and consists of a heating section and a humidifier which supplies saturated vapor at 100°C. Air enters the heating section at 10°C and 70% relative humidity at a rate of 70 m³/min, and it leaves the humidifying section at 20°C, 60% relative humidity.

a) What is the temperature and relative humidity of the air after the heating section?
b) What is the rate of heat transfer in the heating section?
c) What is the flow rate of steam into the humidifier?

Section 4 (Optional – this will replace Test#4)

1) A gas mixture consist of N₂ and O₂ in a molar ratio of 3:1. The mixture is heated during a steady flow process from 180 K to 210 K at a constant pressure of 8 MPa. Determine the heat transfer per mole of mixture.

2) A jet fuel has the approximate composition CH₁.₉₃ and has an enthalpy of formation of -1,770 kJ/kg (note this is mass basis). This fuel at 298 K is combusted with 100% theoretical air at 298 K and the products are at 2400 K, 100 kPa.

a) Write the balanced reaction equation.
b) At what temperature will condensation of moisture in the products occur? (What is the dew point temperature of the products?)
c) How much heat is transferred during the combustion?